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PREDICTED SEAFLOOR SUBSIDENCE PROFILE DATA USING BOTH A 'NORMAL AND MODIFIED' NCB SUBSIDENCE ENGINEERS HANDBOOK METHOD FOR THE PHALEN MINE, SYDNEY COALFIELD, N.S.

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by

T.R.C. Aston*

SUMMARY

The report summarises predicted seafloor subsidence profile data, calculated using both a 'normal and modified' NCB Subsidence Engineers Handbook method, for the single seam workings of the Phalen Mine, Sydney Coalfield, Nova Scotia. The modified version involved changing the tensile strain prediction factor 'k' from a variable (0.55 to 0.85) to a constant (0.80) for different panel width/depth ratios.

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DONNÉES SUR LE PROFIL DE LA SUBSIDENCE DE LA LITHOSPHÈRE OCÉANIQUE OBTENUES EN APPLIQUANT LES MÉTHODES "RÉCULIÈRES ET MODIFIÉES" DU NCB SUBSIDENCE ENGINEERS HANDBOOK METHOD À LA MINE PHALEN, À LA HOUILLÈRE DE SYDNEY, N.É.

par T.R.C. Aston*

RÉSUMÉ

L'auteur présente un résumé des données sur le profil de la subsidence de la lithosphère océanique, obtenues en appliquant la "méthode régulière et la méthode modifiée" du NCB Subsidence Engineers Handbook Method dans le cas des travaux en couche simple à la mine Phalen, à la houillère de Sydney en Nouvelle-Écosse. L'utilisation de la technique modifiée a nécessité le changement du coefficient de prédiction de la déformation due à la traction "k" d'une variable (0,55 à 0,85), à une constante (0,80), pour les différents rapports largeur/profondeur des panneaux.

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INTRODUCTION

The Cape Breton Coal Research Laboratory (CBCRL) has developed a computer program (1,2) which undertakes the calculation of subsidence profiles using the methods given in the National Coal Board Subsidence Engineers Handbook (NCB SEH) (3). Predicted seafloor subsidence values and maximum tensile and compressive strains, calculated using the NCB SEH method, have been calculated for the single seam workings of the Prince, Lingan and No. 26 Mines, Sydney Coalfield (4).

At the request of the Cape Breton Development Corporation (CBDC), the tensile strain prediction factor 'k' was altered within the original NCB SEH program. A report summarising the predicted seabed subsidence profile parameters, using the 'modified' NCB SEH program, for the single seam workings of the Prince, Lingan and No. 26 Mines is given elsewhere (5).

This report summarises the predicted seafloor subsidence profile parameters of maximum subsidence, maximum tensile and compressive strain, calculated using both the NCB SEH and 'modified NCB SEH' programs for the planned Phalen Mine 1 to 3 West and 1 to 4 East longwall panels.

SUBSIDENCE CALCULATION

All subsidence calculations for this report were undertaken using the 'SUB#4' and 'modified' SUB#4 computer programs (1,2,5). The program is written in BASIC A Version 3.10 for use on an IBM-PC/AT microcomputer and undertakes the calculation and plotting of longwall subsidence profiles using the methods given in the NCB SEH (3).

'MODIFIED' SUB#4 PROGRAM

The universally accepted equation for deriving the maximum tensile strain of a subsidence profile is (3,6):

$$E_m = k\frac{S_m}{D} \qquad \text{Eq. 1}$$

E_m = Maximum tensile strain

k = Mining/geological coefficient varying between 0.5 and 1.0

S_m = Maximum subsidence

D = Depth of working

In the NCB SEH prediction method ('SUB#4' program), the value of 'k' varies between 0.55 (width/depth ratio of 0.20) and 0.65 (width/depth ratio of 1.4). The 'k' value reaches a maximum of 0.85 at a width/depth ratio of 0.46 (3).

In the modified version of 'SUB#4', requested by CBDC, the value of 'k' was altered to equal 0.80 for all width/depth ratios, Table 1.

PROGRAM INPUT

To obtain the necessary data for input to both the 'SUB#4' and 'modified SUB#4' programs, a 1:5000 scale plan of the Phalen Mine was examined and the following information tabulated:

Colliery and Seam Name
Panel Identification Number
Panel Width (metres)
Seam Thickness (metres)
Panel Length (metres)
Depth of Cover - mean main and tailgate elevations (metres)
Panel Gradient - across the panel (1 in x)

OUTPUT INTERPRETATION

The NCB Subsidence Engineers Handbook is often viewed as a definitive work on subsidence prediction. However, this can be an erroneous assumption, since it was empirically derived from a data base collected in a variety of U.K. coalfields. Problems occur when it is used in coalfields which were either not included or only poorly represented in the original data base. Similarly, when using empirical methods, it is difficult to quantify the effects of individual parameters such as geology or the presence of existing workings in adjacent seams on the eventual magnitude of the subsidence profile. Caution must therefore be used when applying the NCB SEH to coalfields in countries other than the U.K., even when the conditions to

Width/Depth Ratio	NCB SEH 'k' value	CBDC 'Modified' 'k' value
0.20	0.55	0.80
0.30	0.70	0.80
0.40	0.80	0.80
0.50	0.80	0.80
0.60	0.80	0.80
0.70	0.70	0.80
0.80	0.65	0.80
0.90	0.65	0.80
1.00	0.65	0.80
1.10	0.65	0.80
1.20	0.65	0.80
1.30	0.65	0.80
1.40	0.65	0.80

Table 1 - NCB SEH and CBDC 'modified' 'k' values for prediction of maximum tensile strain

which it is applied are comparable to the coalfields from which the original case histories were collected.

If the Sydney Coalfield is assumed to be similar to the U.K. coalfields, various assumptions and limiting criteria recognised and considerable caution exercised, the 'SUB#4' and 'modified SUB#4' programs can be used to obtain a 'good first order approximation' of the actual subsidence profiles.

PHALEN MINE

At Phalen Mine, mining is restricted to single horizon working in the Phalen Seam. However, the proposed panels will undermine historical workings (assumed to be geologically stable) in the overlying Harbour Seam (No. 14 Colliery and Lingan Mine).

The workings consist of single entry retreat longwalls with inseam gateroads. At present, only two panels are working, 1 East and 1 West, although the proposed layout for the 1 to 3 West and 1 to 4 East panels is shown in Figure 1. Mining parameters for the seven panels identified are given in Table 2, but can be summarised as follows:

Parameter	East Side	West Side
Panel Width (m)	150	150
Mean Extracted Seam Height (m)	2.55-2.65	1.85
Depth of Working (m)	275-425	375-440
Panel Length (m)	2300-2500	1400-1600
Mean Seam Gradient (1 in x)	4.5-4.7	5.5-6.3
Mean Pillar Width (m)	70-100	60

SUBSIDENCE PARAMETERS

Predicted seafloor maximum subsidence, compressive and tensile strain values along with the corrected tensile strain values for mean seam gradient have been calculated. Tables 3 and 4 show the 'SUB#4' and Tables 5 and 6 the 'modified SUB#4' predicted seafloor subsidence parameters for the mean and maximum extracted seam height values.

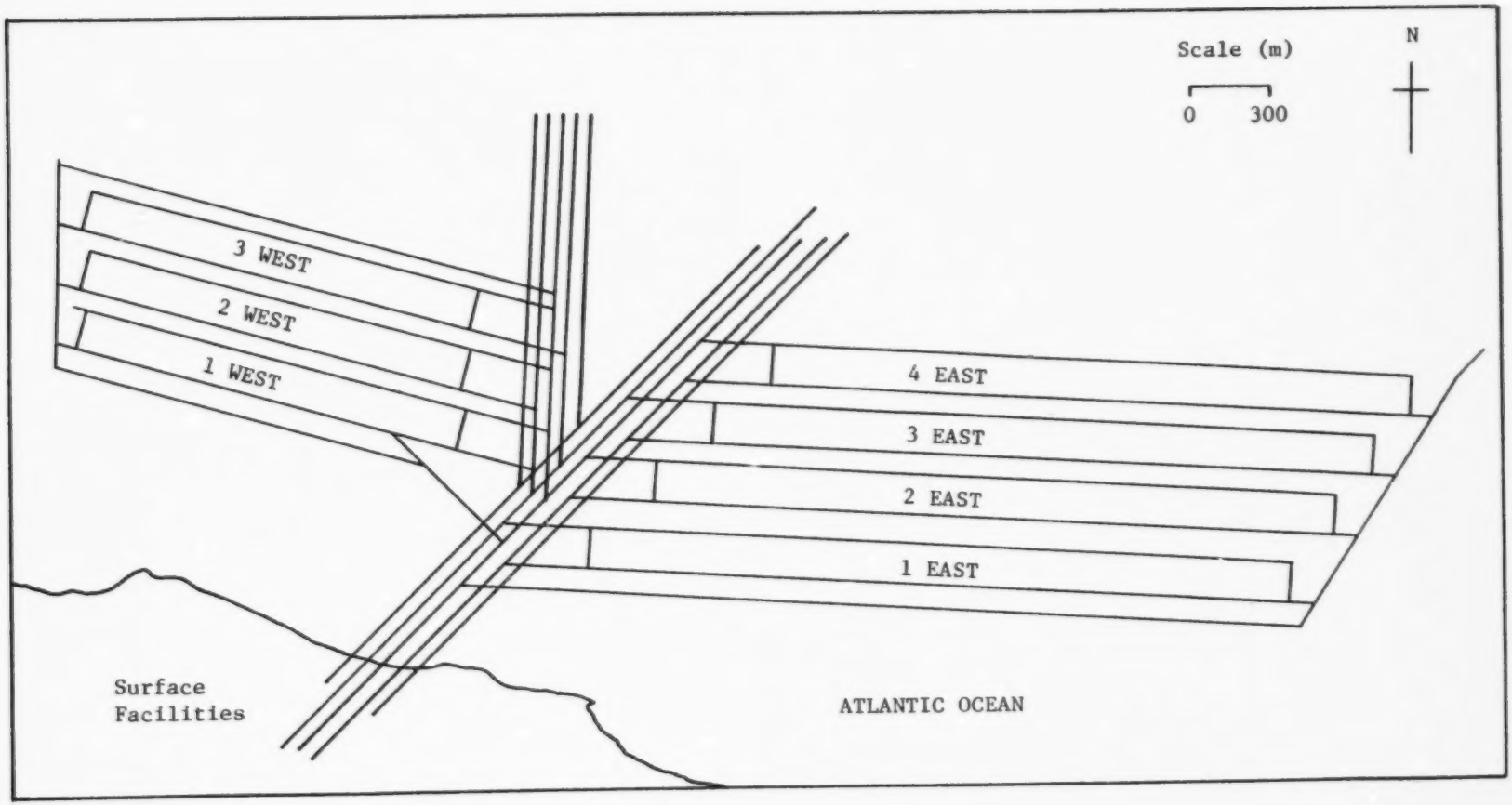

Figure 1 - Phalen Mine

Panel	Face Width (m)	Panel Length (m)	Extracted Seam Ht (m)			Depth of Cover (m)	Seam Gradient (1 in x)
			Max	Min	Mean	Mean	Mean
1 West	150	1400	3.00	1.55	1.85	375	5.5
2 West*	150	1600	3.00	1.55	1.85	420	6.3
3 West*	150	1600	3.00	1.55	1.85	440	6.3
1 East	150	2500	2.85	2.45	2.65	275	4.7
2 East*	150	2420	2.85	2.45	2.65	325	4.5
3 East*	150	2350	2.85	2.45	2.65	375	4.7
4 East*	150	2300	2.70	2.40	2.55	425	4.7

*Panel not yet worked.

Table 2 - Mining Parameters - Phalen Mine

Panel	Mean Extracted Seam Ht (m)	Max Subsidence (m)	Maximum Strain (mm/m)		Gradient (1:x)	Corrected Tensile Strain For Gradient (mm/m)	
			Tensile	Compressive		Rise	Dip
1 West	1.85	0.67	1.42	3.02	5.5	0.98	1.86
2 West*	1.85	0.57	1.09	2.53	6.3	0.82	1.37
3 West*	1.85	0.56	1.01	2.33	6.3	0.76	1.26
1 East	2.65	1.40	4.09	5.87	4.7	2.53	5.64
2 East*	2.65	1.19	2.94	5.32	4.5	1.76	4.11
3 East*	2.65	0.95	2.04	4.32	4.7	1.26	2.81
4 East*	2.55	0.77	1.44	3.33	4.7	0.89	1.99

*Panel not yet worked.

Table 3 - Subsidence data (mean extracted seam height) - Phalen Mine (NCB Subsidence Engineers Handbook)

Panel	Max Extracted Seam Ht (m)	Max Subsidence (m)	Maximum Strain (mm/m)		Gradient (1:x)	Corrected Tensile Strain For Gradient (mm/m)	
			Tensile	Compressive		Rise	Dip
1 West	3.0	1.08	2.30	4.90	5.5	1.59	3.02
2 West*	3.0	0.93	1.77	4.10	6.3	1.33	2.21
3 West*	3.0	0.90	1.64	3.78	6.3	1.23	2.05
1 East	2.85	1.51	4.39	6.32	4.7	2.72	6.06
2 East*	2.85	1.28	3.16	5.72	4.5	1.89	4.42
3 East*	2.85	1.03	2.19	4.65	4.7	1.36	3.02
4 East*	2.70	0.81	1.52	3.53	4.7	0.95	2.10

*Panel not yet worked.

Table 4 - Subsidence data (maximum extracted seam height) - Phalen Mine (NCB Subsidence Engineers Handbook)

Panel	Mean Extracted Seam Ht (m)	Max Subsidence (m)	Maximum Strain (mm/m)		Gradient (1:x)	Corrected Tensile Strain For Gradient (mm/m)	
			Tensile	Compressive		Rise	Dip
1 West	1.85	0.67	1.42	3.02	5.5	0.98	1.86
2 West*	1.85	0.57	1.09	2.53	6.3	0.82	1.37
3 West*	1.85	0.56	1.01	2.33	6.3	0.76	1.26
1 East	2.65	1.40	4.09	5.87	4.7	2.53	5.64
2 East*	2.65	1.19	2.94	5.32	4.5	1.76	4.11
3 East*	2.65	0.95	2.04	4.32	4.7	1.26	2.81
4 East*	2.55	0.77	1.44	3.33	4.7	0.89	1.99

*Panel not yet worked.

Table 5 - Subsidence data (mean extracted seam height) - Phalen Mine (modified SUB#4 program)

Panel	Max Extracted Seam Ht (m)	Max Subsidence (m)	Maximum Strain (mm/m)		Gradient (1:x)	Corrected Tensile Strain For Gradient (mm/m)	
			Tensile	Compressive		Rise	Dip
1 West	3.0	1.08	2.30	4.90	5.5	1.59	3.02
2 West*	3.0	0.93	1.77	4.10	6.3	1.33	2.21
3 West*	3.0	0.90	1.64	3.78	6.3	1.23	2.05
1 East	2.85	1.51	4.39	6.32	4.7	2.72	6.06
2 East*	2.85	1.28	3.16	5.72	4.5	1.89	4.42
3 East*	2.85	1.03	2.19	4.65	4.7	1.36	3.02
4 East*	2.70	0.81	1.52	3.53	4.7	0.95	2.10

*Panel not yet worked.

Table 6 - Subsidence data (maximum extracted seam height) - Phalen Mine (modified SUB#4 program)

Using the 'SUB#4' program, the maximum predicted subsidence varies between 1.08 m (1 West panel) and 1.51 m (1 East panel). The associated maximum corrected tensile strains vary between 3.02 mm/m (1 West panel) and 6.06 mm/m (1 East panel). It is interesting to note that both the 'SUB#4' and 'modified SUB#4' programs produced identical maximum tensile strain values for each of the longwall panels examined.

DISCUSSION

Two constraints exist regarding the mining of undersea mineral reserves: depth of cover and seabed strains. In the Sydney Coalfield, the amount of cover between seabed and the mining horizon is governed by the Canadian Labour Code - Coal Mines (CBDC) Safety Regulations (7), which state:

> Section 115 - No mine shall be worked below the sea bottom or below any other body of water except under the following conditions:
>
> a) No submarine seam of coal or stratified deposit shall be worked under less cover than 180 ft (55 m) of solid measure, except that an owner or lessee of any area may drive passageways to win the mineral to be worked and such passageways may have a cover less than 180 ft (55 m) but not less than 100 ft (30.5 m) of solid measure.

The current maximum allowable tensile strain at seabed, in the Sydney Coalfield, is 8.5 mm/m. This value was recommended in a report submitted by K. Wardell and Partners (8) to the 1974 Commission of Inquiry into undersea mining in Cape Breton. The derivation and applicability of this value to the Sydney Coalfield is fully discussed elsewhere (6).

At each of the three mines examined, Prince, Lingan and No. 26, the longwall panels have all been worked at depths exceeding the 55 m limit imposed by the Canadian Labour Code. In addition, the predicted seafloor tensile strains (using the NCB SEH) have all remained below the 8.5 mm/m value recommended by K. Wardell and Partners (4,5). At Phalen Mine, the

greatest predicted seafloor tensile strain is 6.06 mm/m over the 1 East panel. Also, alteration of the 'k' factor resulted in no changes to the predicted maximum tensile strain values for any of the panels examined.

It is generally recognised that the NCB SEH cannot be used to accurately predict subsidence profiles in the U.S. Appalachian and mid-West Coalfields. However, it should be noted that although the Sydney Coalfield appears to be a northern extension of the Appalachian Coalfield, it also bears marked geological/structural similarities to the British Coalfields. It is therefore concluded, that given the wide range of conditions under which the NCB SEH data was collected, the SEH can be applied to the Sydney Coalfield providing it is realised that the error may be greater than the ±10% normally quoted (6).

CONCLUSION

An analysis of subsidence profiles for the Phalen Mine, using both the 'SUB#4' and 'modified SUB#4' programs, reveals that the maximum predicted seafloor tensile strain is 6.06 mm/m over the 1 East panel. This value lies well within the 8.5 mm/m guideline value currently used in the Sydney Coalfield, N.S.

Finally, because of the uncertainty regarding the application of both the 'normal and modified' NCB SEH to the Sydney Coalfield, it is recommended that the results obtained be used with caution and assumed to be a 'good first order approximation' of the actual profiles developing.

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